

## Real Personal Income and Regional Price Parities

RPPs are price indexes that measure geographic price level differences for one period in time within the United States. For example, if the RPP for Washington DC is 120, prices in DC are on average 20% higher than the U.S. average. An RPP is a weighted average of the price level of goods and services for the average consumer in one geographic region compared to all other regions in the U.S. BEA's estimates of real personal income consist of the current dollar estimates adjusted by the RPPs and converted to constant dollars using the U.S. PCE price index.

*Limitations:* The RPPs use only price and expenditure-related survey data that are collected by U.S. federal agencies. These include the BLS' CPI price survey and the Census Bureau's ACS housing survey. The former was not designed for place-to-place comparisons and does not fully represent smaller geographic units. We therefore use a five-year rolling average of the CPI price data to smooth out inconsistencies that arise when there are items that are sparsely surveyed on a regular basis in the smaller geographies. The Census' ACS data contains detailed geographic information on the cost of rental housing, but limited information on owner-occupied housing values. In this case, we use annual data, but only the price level for renters, not for owners. We impute owner-occupied rent expenditures - by combining the BLS housing estimates of owner-equivalent rents with the ACS data.

*History:* The BEA, in a joint project with the Bureau of Labor Statistics (BLS), first estimated regional price parities for consumption goods and services for 38 metropolitan and urban areas of the U.S. for 2003 and 2004 (Aten 2005, 2006). These areas, for which BLS produces the Consumer Price Index (CPI), represent about 87% of the total population. The method was expanded to cover the remaining nonmetropolitan portions of each state. Prototype estimates for 2005 and 2006 were reported in the Survey of Current Business in November 2008 (Aten 2008, and Aten & D'Souza 2008). Experimental estimates for 2007 incorporate the multi-year American Community Survey (ACS) from the Census Bureau, as do official estimates for 2008 forward. Publications describing these results may be found at <http://www.bea.gov/research/topics/regional.htm>.

*Methods:* The methods and results involve a two-stage, rolling average estimation process. The first stage estimates annual multilateral price level indexes for CPI areas<sup>1</sup> and for several consumption expenditure classes such as apparel, food and transportation. In the second stage, the price levels and expenditure weights<sup>2</sup> are allocated from CPI areas to all counties in the United States.<sup>3</sup> They are then recombined for regions, such as states and metropolitan areas, and merged with data on rents from the Census Bureau's American Community Survey (ACS). The ACS provides more detailed geographic

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<sup>1</sup> The 38 CPI index areas are designed to represent the U.S. urban and metropolitan population. Of the 38 areas, 31 represent large metropolitan areas, 4 represent small metropolitan regions, and 3 represent urban nonmetropolitan regions. For more information on these BLS-defined areas, see [www.bls.gov/cpi](http://www.bls.gov/cpi). A list of the counties sampled in each area can be found in Aten (2005).

<sup>2</sup> Expenditure weights used in the CPI are known as cost weights, and are derived from BLS Consumer Expenditure (CE) survey data. See the "Consumer Price Index" in the *BLS Handbook of Methods*, Chapter 17 at [www.bls.gov](http://www.bls.gov).

<sup>3</sup> For a description of input data and methods used to estimate RPP expenditure weights, see Figueroa, Aten and Martin (2014).

coverage than the CPI areas, including county-level data, thus allowing us to augment the allocated CPI price levels with observed housing observations.

The final RPPs are calculated by stacking five years of the first-stage results, plus the annual rent indexes, and calculating the multilateral aggregate price index for all goods and services and rents. For example, the 2010 RPP is a five-year average of the 2008-2012 CPI-derived price indexes for goods and services excepting rents, plus the 2010 rent indexes from the ACS.

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The following sections describe in more detail the methods: the use of the price levels and expenditure data from the CPI and the housing data from the ACS, how their geographies are reconciled, and how the overall indexes are computed.

### *I. Price levels for CPI areas*

CPI price data cover a wide array of consumer goods and services, ranging from high-expenditure goods, such as new automobiles, to low-expenditure services, such as haircuts. Over a million price quotes are collected each year and are classified into more than 200 item strata, each consisting of detailed Entry Level Items (ELIs), which may be further divided into clusters. The item strata can be combined into nine expenditure groups: apparel, education, food, housing, medical, recreation, rents, transportation and other goods and services.<sup>4</sup>

Because the CPI was not designed to measure geographic price level differences, items with identical characteristics are not always priced in all areas. Therefore, for the ELIs and clusters in the 75 highest item strata (accounting for roughly 85 percent of expenditure weights), we estimate hedonic regressions which take into account the variation in the characteristics of the sampled items.

For the “Women’s Tops Excluding Active and Outerwear” cluster, for example, we use a hedonic price model to adjust for the type of clothing (jacket, sweater or blouse), the fiber content, the length of the sleeves, the closure type, the size range, the brand category (exclusive/luxury, national or private), country of origin, and the type of outlet where it was sold. An example of an item-specific hedonic regression may be found in Aten (2006).

For the remaining item strata, a shortcut approach is used consisting of a single weighted regression only on areas and ELI’s (and clusters when available) as independent variables. Overall results do not differ greatly whether detailed hedonic regressions are run on all item strata, or only on the top 75 in combination with this shortcut approach (Aten 2006).

After the ELI price levels are estimated, they are aggregated to yield item strata price levels using a weighted country product dummy (CPD-W) approach, with weights corresponding to the importance of

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<sup>4</sup> See the “Consumer Price Index,” in the *BLS Handbook of Methods*, chapter 17 at [www.bls.gov](http://www.bls.gov).

the ELIs within the item strata.<sup>5</sup> Both the ELI and the item strata price levels undergo an outlier checking process described in detail in Aten, Figueroa and Martin (2011). Briefly, it is modeled after the Quaranta tables.<sup>6</sup> We flag observations that are i) either very large or small relative to the mean in that area and ELI; ii) that are either large or small relative to the variance of the ELI observations; or iii) are large or small once they have been adjusted for the relative price level of the area. It is an iterative process that looks at the raw price data as well as the relative prices after the hedonic adjustment.

Lastly, the item strata price and expenditure levels in each of the 38 areas are aggregated to 16 expenditure classes using the Geary multilateral index (see Balk 2009).<sup>7</sup> One of the advantages of the Geary index is that it is additive at various levels of aggregation. Previous research on the RPPs (Aten and Marshall 2010) has shown that other methods such as the EKS-Törnqvist and Fisher indexes, the CPD-W approach, and a GAIA index, tend not to deviate greatly from the Geary.<sup>8</sup>

The Geary multilateral price level index,  $P_{Geary}$ , is given by:

$$P_{Geary}^c = \frac{\sum_{n=1}^N (pq)_n^c}{\sum_{n=1}^N \pi_n q_n^c}$$

$$\pi_n = \sum_{c=1}^M \frac{(pq)_n^c}{P_{Geary}^c \sum_{d=1}^M q_n^d}$$

Where:  $p$  is the relative price of the item stratum or expenditure class

$\pi$  is the national average price of the item stratum or expenditure class

$q$  is the notional quantity equal to  $(pq)/p$

$c$  and  $d$  are regions, which take a value of 1 through M

$n$  is the item stratum or expenditure class, which takes a value of 1 through N

## *II. Regional Price Parities for States and Metropolitan Areas*

The second stage begins with the allocation of price levels and expenditure weights from CPI areas to counties. Price levels for each county are assumed to be those of the CPI sampling area in which the county is located. For example, counties in Pennsylvania are assigned price levels from either the

<sup>5</sup> The CPD-W is the weighted geometric mean when there are no missing observations. For a complete description, see Rao (2004).

<sup>6</sup> The process is modeled after the Quaranta method used by the Organisation for Economic Co-operations and Development, Eurostat, and the International Comparison Program of the World Bank ([www.worldbank.org](http://www.worldbank.org)).

<sup>7</sup> The 16 expenditure classes are derived from the 9 groups subdivided into goods and services: apparel has only goods, rents has only services, and the other seven groups have both goods and services.

<sup>8</sup> The Geary formula is solved simultaneously for the area RPPs and the expenditure class price levels (notation and formulas follow Deaton and Heston 2010).

Philadelphia or Pittsburgh areas or from the Northeast small metropolitan area. Rural counties are not included in any of the 38 urban areas for which stage one price levels are estimated, therefore these counties are assigned price levels of the urban area that (1) is located in the same region and (2) has the lowest population threshold.<sup>9</sup>

Expenditure weights in the second stage include CPI data for rural regions, and thus in combination with the 38 urban areas, cover all U.S. counties. Weights are allocated from each CPI area and rural region to the component counties in proportion to household income.<sup>10</sup> The county-level allocations undergo two adjustments. First, the distribution of rent weights is replaced with one based on directly observed rent expenditures from the 5-year ACS file *plus* imputed owner-equivalent rent expenditures. The latter are obtained as follows:

1. The ratios of monthly tenant rents to owner-equivalent rents in the BLS CPI housing file are estimated for several types of housing units, from studio apartments to detached houses with three or more bedrooms. The components of these ratios, that is, tenant rents and owner-equivalent rents for each housing type, are the weighted geometric means of all the observations in the CPI.
2. The ratios are applied to the observed unit rents in the ACS, resulting in an estimated monthly owner-equivalent rent value for each housing type, by county;<sup>11 12</sup>
3. This estimated owner-equivalent rent value is multiplied by twelve and by the number of owner-occupied housing units in each type, resulting in an annual estimate of owner-occupied housing expenditures, by county.

Note that the ratio of tenant rents to owner-equivalent rents is across all BLS sampling areas, that is, there is only one vector of ratios for each housing type. The same ratio is applied to different geographies in the ACS file, with only the distribution of rents and number of units varying across geographies.<sup>13</sup> Total expenditures by tenants and owners is equal to the sum of the observed annual rent expenditures and the estimated owner-occupied expenditures from step 3 above.

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<sup>9</sup> Price levels in rural counties in the South, Midwest and West regions are assumed to be the same as those in the BLS urban, nonmetropolitan area for the region. BLS has no urban, nonmetropolitan area for the Northeast so rural counties are assumed to have the same price levels as those in the BLS-defined small, metropolitan area for the Northeast.

<sup>10</sup> The allocation uses county-level ACS Money Income. Money income is defined as income received on a regular basis (exclusive of certain money receipts such as capital gains) before payments for personal income taxes, social security, union dues, Medicare deductions, etc. Therefore, money income does not reflect the fact that some families receive part of their income in the form of noncash benefits. For more information, see [www.census.gov](http://www.census.gov). In past papers, population was used to distribute the weights; for a comparison, see Figueroa, Aten and Martin (2014).

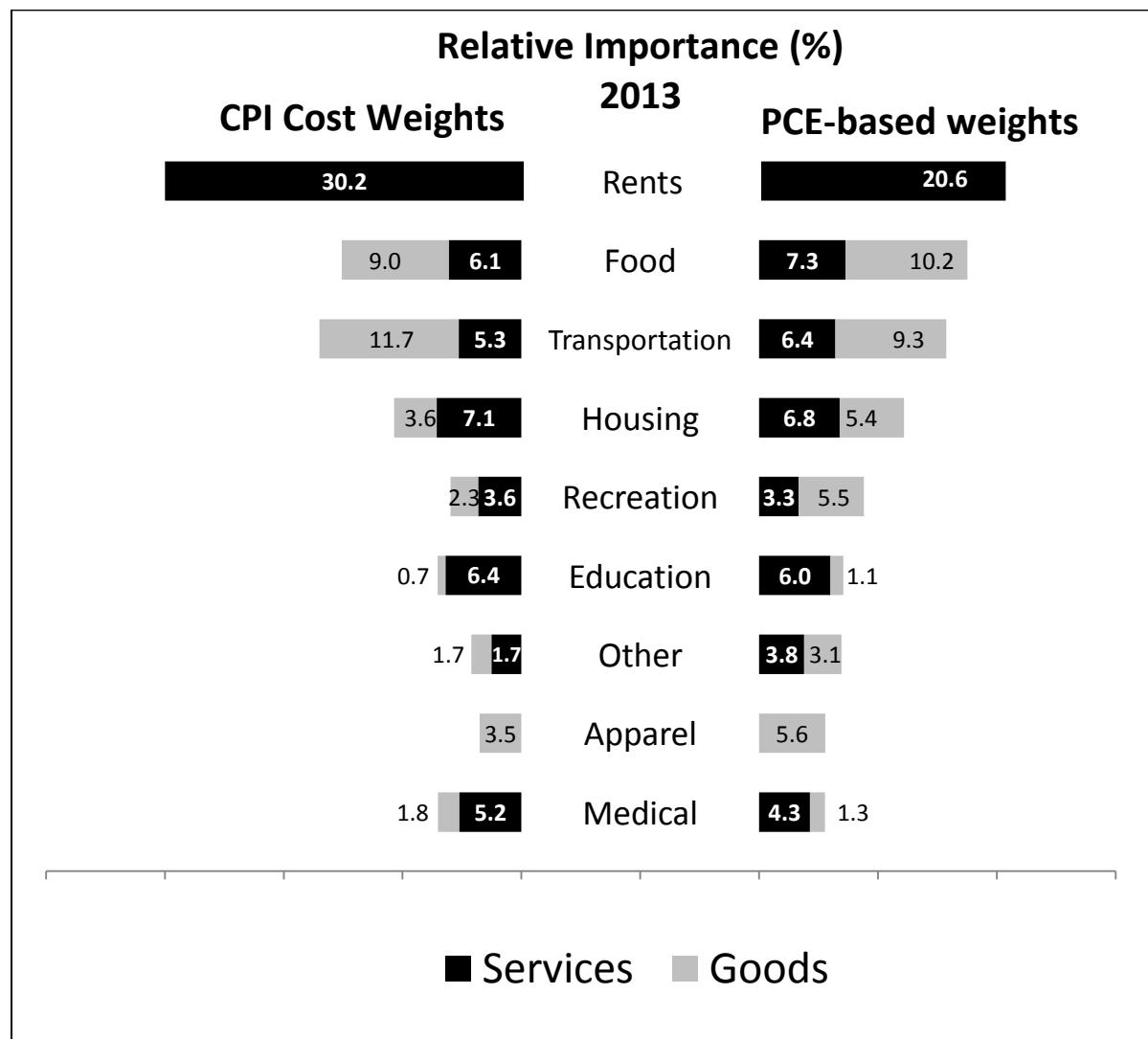
<sup>11</sup> Unit rents are the sum of rent expenditures divided by the number of units of each housing type for each area.

<sup>12</sup> In earlier work (Aten 2005, 2006), we imputed BLS owner-equivalent rent price levels to other geographies. Here, we only use the BLS data to obtain owner-equivalent rent expenditures; we do not impute owner-equivalent rent price levels.

<sup>13</sup> For more information on how the RPP program estimates expenditures on owner-occupied rents, see Figueroa, Aten, and Martin (2014).

The second adjustment to the county level weights is to control the national shares of the 16 expenditure classes to BEA's personal consumption expenditure shares. This yields weights consistent with BEA's national accounts.<sup>14</sup> The adjustment shifts the distribution of weights across expenditure classes, notably reducing the share of rents expenditures from total consumption in the United States from 30.2 percent to 20.6 percent (Chart 1).

**Chart 1. Relative Expenditure Weights: CPI and PCE-based**



Once the county price levels and expenditure weights have been obtained for each class and for each year as outlined above, we take the weighted geometric mean of the price levels for states, state

<sup>14</sup> The adjustment is based on BLS research providing PCE-valued weights for CPI item strata (Blair 2012).

metropolitan and nonmetropolitan portions, and metropolitan areas. This weighted geometric mean is a five-year rolling average for goods and services other than rents.

Rent price levels are estimated directly from tenant rent observations in the ACS: annually for states, and across 3 years for metropolitan areas. No imputation of owner-occupied rents is used in the price levels, instead we use rent price levels for both renters and owners.<sup>15,16</sup> The rent price level estimates are quality-adjusted using a hedonic model that controls for basic unit characteristics such as the type of structure, the number of bedrooms and the total number of rooms, when the structure was built, whether it resides in an urban or rural location, and if utilities are included in the monthly rent. Additional research comparing rent price levels estimates using the ACS and CPI Housing surveys is available in Martin, Aten, and Figueroa (2011).

In the second multilateral aggregation we use the five-year rolling average for the 15 expenditure classes derived from the BLS CPI, together with the one-year state level rents and three-year metropolitan area rents from the Census ACS to estimate the final all items RPPs. For expenditure weights, we use one-year files for states and three-year files for metropolitan areas.

The multi-year rolling averages imply that for 2010, for example, final state-level RPPs are composed of rent price levels in 2010 plus an average of the price levels for goods and services other than rents between 2008 and 2012 (Table 1).

### *III. Using RPPs to estimate real personal income*

An important application of the RPPs is to control for price level differences across regions when measuring economic activity such as income levels. The price level differences measured by the RPPs are specific to one point in time. At BEA, we make an additional adjustment to convert the regional current dollar values to constant values, resulting in price-adjusted regional incomes at chained dollars, which we call “real” personal income.<sup>17</sup>

Real personal income in chained (2009) dollars for a region is the current-dollar personal income divided by its RPP for a given year, and balanced so that the sum of personal income remains the same before and after the adjustment. The RPP-adjusted results (equal to current dollar income in regional prices)

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<sup>15</sup> In Aten and D’Souza (2008), the imputation for county-level owner-occupied rent levels used owner’s monthly housing cost data from the 5-year ACS housing file, together with the annual CPI Housing Survey from BLS. In more current work (Aten, Figueroa, and Martin 2011, 2012), only observed rent price levels from the ACS were used, making no imputations for the owner-occupied rent levels. The monthly housing costs in the ACS include mortgage payments, but do not specify the term or interest rate of the loan. The coverage and distribution of the reported payments was highly variable, and using that information has been postponed until more data or further research is completed.

<sup>16</sup> ACS data for 2012 did not incorporate a revision made by BEA to its MSA definitions (see Survey of Current Business, “Comprehensive Revision of Local Area Personal Income”, December 2013, page 17.) Among other changes, the revision designated 23 new MSAs. ACS rents for these MSAs were estimated from ACS data for state metropolitan and nonmetropolitan portions.

<sup>17</sup> Personal income is defined as the income received by all persons from all sources. It is the sum of net earnings by place of residence, property income, and personal current transfer receipts. For more information, see [www.bea.gov/regional](http://www.bea.gov/regional).

are divided by the U.S. PCE price index, which converts the current dollar value to 2009 chained dollars. For the U.S., the nominal and real personal income totals will equal in other in 2009, while the regional nominal and real personal incomes will differ only by the balanced RPP of each region.

Here is an example of the price adjustment for the state of Connecticut in 2013 (billions of dollars)<sup>18</sup>:

$$\text{RPP Adjusted Personal Income (PI)} = \frac{\text{Current Dollar PI}}{\text{RPP} * \text{Balancing Factor}} = \frac{\$218.1}{1.085 * 0.99} = \$201.2$$

$$\text{Real Personal Income (2009 Dollars)} = \frac{\text{RPP Adjusted PI}}{\text{PCE Price Index}} = \frac{\$201.2}{1.073} = \$187.5$$

The implicit regional price growth rate is the change in RPPs between two years times the change in the U.S. PCE price index (see Box below titled “Implicit Price Growth Rates”).

### Implicit Price Growth Rates

The RPP indexes express a region’s average price relative to the U.S. average, that is,<sup>19</sup>

$RPP_{i,t} = (P_i / P_{US})_t$  where  $i$  is the region and  $t$  is the time period.

The implicit price growth or regional inflation may be calculated as:

$(P_{i,t} / P_{i,t-1}) = (RPP_{i,t} / RPP_{i,t-1}) * (P_{US,t} / P_{US,t-1})$ , where the US price change is measured by the national PCE price index.

The real personal income statistics in this article use the RPPs to measure the change in price level differences across regions and the national PCE price index to capture the U.S. price change over time.

### IV. Publication Schedule

Estimates of Real Personal Income and Regional Price Parities are published annually, roughly a year and half after the reference year. This delay is due to the complexity of RPP estimation methods and the release schedule of inputs, in particular the rents data from the ACS which are available only in the fall months following the reference year.

The estimates are published for three sets of geographies: states (including the District of Columbia), state metropolitan and nonmetropolitan portions, and metropolitan statistical areas. RPPs for

<sup>18</sup> The example uses current-dollar state personal income estimates that were released on September 30, 2014.

<sup>19</sup> The RPP indexes are multilateral indexes that compare area prices with national prices. National prices are defined as quantity-weighted averages of the local area prices of each good. The national prices and the RPPs are solved simultaneously (see the section “Data and Methodology”).

metropolitan areas include the nonmetropolitan portion of the United States to provide complete coverage of all US counties.

The estimates are regularly revised, in part to reflect revisions in current dollar personal income – see methodologies for State and Local Area personal income on the BEA website – but also because of the availability of new source data for constructing the RPPs. As discussed above, the estimation uses five year rolling average data for price levels other than rents. When initially released, the RPPs use rolling average data ending in the reference year. For example, in July 2015, the newly released estimates for 2013 used a rolling average price level data covering 2009 to 2013. In 2016, these “initial” estimates for 2013 will be revised using a dataset covering 2010 to 2014. In 2017, these “revised” estimates will become “final” with the availability of a rolling average dataset for 2011 to 2015, centered on the 2013 reference year.

**Table 1. Revision status and price level source data, by RPP reference year:**

			2008	2009	2010	2011	2012	2013
Price Level	Region	Source	Final	Final	Final	Final	Revised	Initial
Rents	States and Portions	ACS	2008	2009	2010	2011	2012	2013
	Metropolitan Areas	ACS	2006-2008	2007-2009	2008-2010	2009-2011	2010-2012	2011-2013
Other	All	CPI	2006-2010	2007-2011	2008-2012		2009-2013	

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## **Disclaimer**

The BEA Regional Price Parity statistics are based in part on restricted access Consumer Price Index data from the Bureau of Labor Statistics. The BEA statistics expressed herein are products of BEA and not BLS.